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An Anomia Treatment Using Orthographic-phonological Cue and Phonological Priming in A Cantonese Aphasic Patient

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Abstract

The present study utilized a single subject multiple baseline design to investigate the treatment effectiveness of anomia treatment using orthographic-phonological cue and phonological priming on a 61-year old Cantonese anomic patient. Generalization effect to semantically related and phonologically related items was separately investigated. The treatment was effective in improving word-retrieval ability on treatment items. Specific generalization effect was found in phonological generalization items. The treatment effect was able to maintain for at least one and a half month after the end of treatment. The possible reasons for insignificant gain in semantic generalization items were discussed. Comparing the treatment effect of the present study to previous studies may suggest that phonological priming can facilitate generalization to phonologically related items.

An Anomia Treatment Using Orthographic-phonological Cue and Phonological Priming in A Cantonese Aphasic Patient

Introduction

Difficulty in word retrieval (anomia) is the most pervasive symptom of language breakdown in aphasia and is noted in nearly all aphasic patients (Dell, Sschwartz, Martin, Saffran & Gagnon, 1997). Anomia disrupts communication and can cause frustration and distress (Raymer & Gonzalez Rothi, 2002). The pervasiveness and persistence of word retrieval difficulties have prompted extensive investigations, some attempting to develop models to explain the underlying deficits while others aiming at developing treatments to ameliorate the difficulties (Goodglass & Wingfield, 1997).

Model of Confrontation Naming

Language processing is governed by multiple modules (Coltheart, 1987). Figure 1 shows the modules involved in confrontation naming with their functions stated in parentheses (Laine & Martin, 1996; Whitworth, Webster & Howard, 2005). Word-retrieval deficits can be caused by disruption in combination of any of these modules and/ or the connections between them (Whitworth et al., 2005).

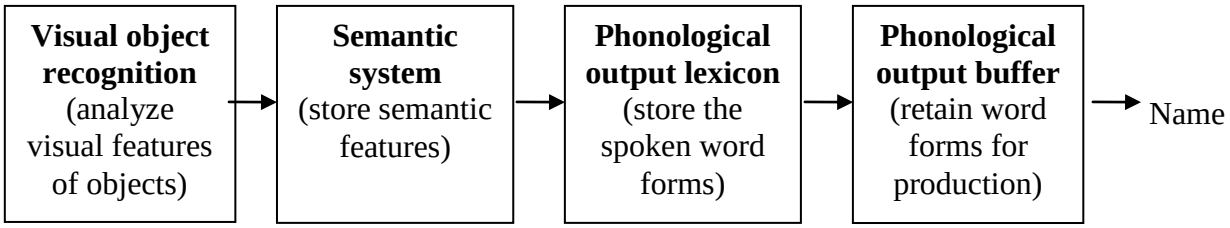

Figure 1. Modules involved in confrontation naming

Approaches in Anomia Treatment

Anomia treatment aims at ameliorate the weakened representation in the modules and/ or the access to them through repeated activation of the weakened representation (Hillis & Caramazza, 1994; Raymer & Ellsworth, 2002). There are two main approaches for treating word-retrieval difficulties: semantic approach and phonological approach (Wambaugh, Linebaugh, Doyle, Martinez, Kalinyak-Fliszar & Spencer, 2001). The semantic approach includes tasks focusing on semantic level of processing, such as judging semantic features (e.g. Grayson Hilton, & Franklin, 1997), categorizing pictures (e.g. Kiran & Thompson, 2001) and matching words to pictures (e.g. Hough, 1993). The phonological approach includes tasks

focusing on phonological level of processing, such as performing rhyme judgments (e.g. Howard, Patterson, Franklin, Orchard-Lisle & Morton, 1985), repeating names of target items (e.g. Li, 1996), naming with phonological cueing hierarchy (e.g., Raymer & Ellsworth, 2002) Besides, there are treatment approaches that involve both semantic tasks and phonological tasks (e.g. Eales & Pring, 1998).

Problems in Previous Anomia Treatment Studies and Contradictory Results Found

Although a large number of studies have been conducted on anomia treatment, many remained methodologically weak (Nickels, 2002). Multiple baseline design is needed in research study to evaluate generalization effect and distinguish effects of treatment from non-specific treatment effects or spontaneous recovery (Nickels, 2002; Shaughnessy & Zechmeister, 2003); however, some anomia treatment studies did not include a generalization task (e.g. Jokel & Rochon, 1996; Pedersen, Vinter & Olsen, 2001) while some did not include a control task (e.g. Deloche, Dordain, Kremin, 1993; Eales & Pring, 1998). Also, Renvall, Laine, Laakso and Martin (2003) and Thompson, Kearns and Edmonds (2006) mentioned that there still was a relative shortage of well-controlled rehabilitation experiments that looked at long-term treatment effects. Besides methodological limitations, some investigations did not analyze the results statistically; instead, they relied on visual inspection of data (e.g. Li, Kitselman, Dusatko & Spinelli, 1988; Kiran, Thompson & Hashimoto, 2001). These make the interpretation of the results difficult. Furthermore, it is still unclear which treatment approach is the most suitable for a particular underlying deficit of anomia (Renvall et al., 2003).

Contradictory results have been found in previous studies. For example, patients with comparable deficits were found to be responding differently to the same treatment approach (e.g. Hickin, Herbert, Best, Howard & Osborne, 2002; Nettleton & Lesser, 1991).

In view of the above, there is a need for more research with sound methodology in anomia treatment.

Anomia Treatment Using Phonological Cues in English-speaking Aphasic Patients

Hickin et al. (2002) mentioned that the emphasis of previous studies was being placed on semantic treatment. There were relatively few studies on anomia treatment using phonological cues. Howard et al. (1985) studied anomia treatment using phonological cueing hierarchy in

which phonological cues were presented in increasing power contingent upon failure to produce a target name. For example, first syllable of the target name was presented upon failure to produce the name with first phoneme given. Howard et al. (1985) found that the treatment improved naming. Best, Herbert, Hickin, Osborne and Howard (2002) and Hickin et al. (2002) also demonstrated the effectiveness of treatment using phonological cues. Concerning the maintenance effects of treatment using phonological cues, Best et al. (2002) and Miceli, Amitrano, Capasso and Caramazza (1996) found that the improvement could be maintained for two months and 17 months after the end of treatment respectively.

Anomia Treatment Studies for Cantonese-speaking Aphasic Patients

There are few studies on anomia treatment for Cantonese aphasic patients as compared with that for English-speaking aphasic patients.

Law, Wong, Sung, and Hon (2006) studied anomic treatment using Semantic Feature Analysis (SFA) and semantic priming. Two of the three subjects improved in naming. However, for the two subjects who had significant improvement, only one of them demonstrated maintenance of treatment effect one month after the therapy was ended. In a subsequent study involving two more patients who received the same treatment protocol, Law (2006) found that one of the two subjects failed to complete the treatment.

In addition, Law (2006) had studied an anomia treatment using orthographic-phonological cue for Cantonese aphasic patients. The treatment was phonologically based which primarily focused on facilitating word retrieval at the phonological level. Orthographic cue (letter cue) refers to provision of the letter which corresponds to the initial phoneme of target name. For example, the orthographic cue 'l' would be provided for the target name 涼鞋 /lœŋ$_{21}$ hai$_{21}$/ (scandal). The subject had to produce possible syllables associated with the orthographic cue. For example, when the orthographic cue 'l' was presented, the subject may produce /la/, /lei/ and /lɐm/ .As the phonological cues (the syllables) were generated upon presentation of the orthographic cue, hence the cue was named 'orthographic-phonological cue'. Pre-treatment training was given to the subjects to enable them to produce self-generated phonological cues. Law (2006) found that all the four subjects demonstrated significant improvement in naming.

Also, treatment gains were maintained for at least one month after the therapy was completed for all subjects.

Patients Who May Benefit from Phonological Treatment

Nickels (2002) mentioned that phonological treatment were appropriate for patients with phonological impairments or semantic impairments. It is because deficits at the phonological output lexicon or weak activation at the semantic level will result in weak activation at the phonological output lexicon; therefore, phonological tasks that increase activation at the phonological output lexicon will increase the chance of retrieval of the target name, no matter the weak activation is due to phonological impairment or semantic impairment. Hillis and Caramazza (1994) and Raymer, Thompson, Jacobs and LeGrand (1993) also claimed that phonological treatments were facilitative regardless of the locus of impairment.

Advantage of Phonological Treatment over Semantic Treatment

Anomia treatment using orthographic-phonological cue has several advantages over that using SFA and semantic priming. Home practice is important for treatment progress; however, for anomic treatment using SFA, independent home practice is not possible for subjects with severe anomia and/ or dyslexia; while independent home practice may be possible for those subjects if treatment using orthographic-phonological cue is given (Law, 2006). In addition, for aphasic patients with severe anomia, the production of various semantic features associated with the target, which is required in the SFA treatment, is likely to be frustrating. Treatment using orthographic phonological cues may avoid the frustration.

Furthermore, previous studies seem to support that phonological treatments can be applied to a greater variety of anomic patients than semantic treatments. Several studies have revealed that therapy using semantic approach is not effective for all aphasic patients. Nettleton and Lesser (1991) found that semantic therapy directed towards rehabilitation of semantic impairment was not effective when the semantic impairment was severe. Law et al. (2006) also found that anomia treatment using SFA and semantic priming was not effective for patient with severe semantic impairment. The study by Pease and Goodglass (1979) revealed that semantic cues were not effective in facilitating naming for patients with severe naming impairment. On

the contrary, Best et al. (2002) found that it was appropriate to use phonological cues with people with severe and mild anomia.

In other words, the use of orthographic-phonological cue in treatment for anomic speakers seems to be a promising treatment and warrants further investigation.

Generalization Effect in Phonological Treatment

Generalization effect has not been clearly revealed in previous studies of anomia treatments that primarily focus on facilitating word retrieval at the phonological level. Miceli et al. (1996) and Nettleton and Lesser (1991) found that the therapy resulted in item specific improvement in trained items. On the other hand, Hillis and Caramarazza (1994), Raymer et al. (1993) and Robson, Marshall, Pring, and Chiat (1998) found generalization to untreated items. However, the nature of the generalization items was not clearly stated in these studies. In the studies by Miceli et al. (1996), Hillis and Caramarazza (1994) and Robson et al. (1998), they mentioned that there was/ was not generalization to 'untrained items' without stating whether the untrained items share any relationship (semantically or phonologically) with the treated items. Raymer et al. (1993) collapsed the semantic generalization items and phonological generalization items by reporting that there was "generalized naming to untrained semantically and phonologically related items" (p.40) without stating the generalization effect for each particular type of items. In addition, Law's (2006) study only investigated generalization to phonologically related items. Therefore, to understand better whether there would be any generalization effect for phonologically based anomia treatment and whether such effect would be related to the nature of the untrained items, generalization items should be distinguished in terms of their relationship with the treatment items, that is, generalization effect to semantically and phonologically related untrained items should be separately studied.

Limited Generalization Effect Found in Treatment Using Orthographic-phonological Cue

Although the use of orthographic-phonological cue in treatment had resulted in significant gain in treatment items in all subjects studied by Law (2006), generalization effect was found to be limited. According to Law (2006), only one of the four subjects showed generalization in one of the two phases of treatment. Another subject showed improvement in naming both generalization items and control items making it possible that the gain in generalization items

was attributed to spontaneous recovery or improvement in general conditions of the subject. In addition, the other two subjects did not improve in naming generalization items. In view of this, further research is needed to find ways to improve generalization effect in the treatment.

Phonological priming has the potential to promote generalization (Martin & Laine, 2000). Interactive activation model postulates that when a word's representation is activated at the semantic and phonological levels, activation will spread to other words that share similar features (e.g. aspects of its meaning or overlapping sound) of that word (Dell & O'Seaghdha, 1992). By naming a group of treatment items that share the same initial phoneme, there should be consistent activation of untrained items with the same initial phoneme and thus should facilitate future retrieval of these untrained items (Foygel & Dell, 2000; Schwartz, Dell, Martin, Gahl & Sobel, 2006).

Overall View for the Present Study

The present study was on anomia treatment for Cantonese aphasic patient. Orthographic-phonological cue was used in the treatment. The phonological cue produced by the subject facilitated word retrieval at the phonological level by partial activation of entries in the auditory input lexicon which feed through to result in partial activation of phonological output lexicon entries. The partial phonological information from the cue combines with activation from the semantic system, resulting in activation of the target name in the phonological output lexicon (Howard & Harding, 1998).

Secondly, the treatment design involved a phonological cueing hierarchy as in Law (2006), that is, phonological cues with increasing power would be given if the subject failed to produce the target name upon orthographic-phonological cue. The use of cueing hierarchy could facilitate long-term improvement of word retrieval (Linebaugh, 2005).

Phonological priming was adopted in the treatment besides the use of orthographic-phonological cue. As mentioned, the use of phonological priming may overcome the disadvantage that treatment using orthographic-phonological cue had limited generalization.

Generalization to phonologically related and semantically related items was separately investigated to better understand the nature of generalization in phonologically based treatment.

This study aimed at answering the following questions – 1) Would the treatment using orthographic-phonological cue and phonological priming be effective for Cantonese-speaking aphasic patients? 2) Would there be any generalization to untrained items? 3) Would the treatment gains be (if any) maintained beyond the treatment phase?

Based on previous findings, the following predictions were made: 1) There should be improvement in naming accuracy of treated items, no matter the subject had impairments in semantic level, phonological level or both. 2) There should be generalization to phonological generalization items as phonological priming was adopted. 3) The generalization effect to phonological generalization items should be greater than that of semantic generalization items because of priming effect. 4) The treatment gains were expected to be maintained beyond the treatment phase.

Method

Participant

CHT, a 61-year-old male, was a native Cantonese speaker and was right-handed. He suffered from ischaemic stroke in September, 2005. CT brain scan revealed left hemisphere infarct involving the frontal-parietal areas. CHT had Form four educational level. He was a mini-bus driver and had retired for six years at the time of study. He had received speech therapy at Tuen Mun Hospital twice a month for two months. He had also received weekly speech therapy jointly offered by the Hong Kong Society for Rehabilitation and the Division of Speech and Hearing Sciences of the University of Hong Kong for three months. Speech therapy had ceased for seven months prior to the study.

Initial Assessments and Hypothesized Underlying Deficits

CHT was classified to have anomic aphasia from the result of a Cantonese version of the Western Aphasia Battery (CAB) (Yiu, 1992) administered in October, 2006. His Aphasia Quotient was 75.3.

Oral naming of pictures adopted from Snodgrass and Vanderwart (1980) revealed that CHT had prominent naming problem in which he only attained 47.47% (103/217) accuracy. A reading aloud task using the same target words as those in the oral naming task revealed that he had disruption in reading aloud as he attained 72.35% (157/ 217) accuracy.

A number of neuropsychological tests were administered to identify the underlying deficits of CHT's naming problem. Three subtests of Birmingham Object Recognition Battery (BORB) were administered, including minimal feature view task, foreshortened view task, and item match task (Riddoch & Humphreys, 1993). CHT achieved 100% (25/25), 96% (24/25) and 100% (32/32) respectively, indicating his visual object recognition was largely preserved.

Non-verbal semantic tests including Pyramid and Palm Tree Test (PPT) (Howard & Patterson, 1992) and associative match test of BORB (Riddoch & Humphreys, 1993) were administered. CHT attained 97.30% (36/37) and 95.65% (22/23) accuracy respectively, indicating his non-verbal system processing was largely intact.

Spoken word picture matching and written word picture matching were implemented. CHT had deficits in spoken word picture matching (89.68% or 113/126) and written word picture matching (90.48% or 114/126), with semantically related errors accounting for most of the failed trials, 92.31% (12/13) and 83.33% (10/12), respectively. CHT's performance in spoken word picture matching and written word picture matching was not significantly different from each other (McNemar $\chi^2 = 0.056$, $p = 0.8137$). These revealed that CHT's deficit in spoken word picture matching and written word picture matching may mainly be attributed to deficit in verbal semantic processing.

CHT attained 83.33% (25/30) in repetition of words. Semantic system is the module involved in both oral naming and spoken word picture matching. CHT's performance on oral naming and spoken word picture matching of the same set of targets was significantly different (McNemar $\chi^2 = 33.018$, $p < 0.0001$), indicating deficits in the phonological output lexicon and/ or the access to it apart from deficits in semantic system.

To sum up, it was hypothesized that CHT's underlying deficits included verbal semantic processes, phonological output lexicon and/ or the access to it.

CHT's had poor preserved knowledge in letters names and letter sounds (e.g. the sound of the letter 's' is the first phoneme of /si/). CHT scored 42.31% (11/26) and 50% (13/26) in naming uppercase letters and lowercase letters respectively. He only attained 8.33% (2/24) accuracy in letter sounding. Also, he scored 50% (13/26) and 26.92% (7/26) in letter name-written letter matching and letter sound-written letter matching respectively.

Materials

A set of 256 black and white line drawings of items belonging to 18 different categories was used. The picture set was selected from Snodgrass and Vanderwart (1980) (n=158), Aphasia Rehabilitation: a clinical and home therapy program outcome (Jipson, 1987) (n=39), British Picture Vocabulary Scale (Dunn, 1982) (n=36), Boston Naming Test (Kaplan, Goodglass & Weintraub, 1983) (n=12) and Picture Please! A Language Supplement (Abbate & Lachappelle, 1979) (n=11). Only items with disyllabic or trisyllabic names were selected because the use of items with monosyllabic names may induce difficulty in making accuracy judgment when the participant made articulatory errors.

Five normal Cantonese-speaking 60–62 years old males, whose age, gender and educational level (Form three to Form five) matched with the subject, were recruited to name the picture set and rate the familiarity of each picture. Pictures with naming agreement of 60% or more (three out of five normal participants or more gave the same name for a certain picture) were selected as the stimuli for baseline phase and the name with agreement of 60% or more was regarded as the 'modal name' (Law et al., 2006). A total of 207 pictures met the criterion.

Treatment Design

Multiple baseline design consisting of four phases namely baseline phase, pre-treatment training phase, treatment phase and maintenance phase was adopted in this study.

Baseline Phase

Three sessions were carried out over two weeks to find out the baseline performance of the subject. In each session, the subject was asked to name the 207 pictures with a time limit of 15 seconds given for each picture. The order of presentation of the pictures was randomized every session. The pictures that the subject failed to name in two or more sessions (n=133) were chosen as the potential stimuli for the treatment phase.

Fifteen items each were selected as the treatment items, phonological generalization items, semantic generalization items and control items, totaling 60 stimuli (see Appendix A). The familiarity ratings of the items across the four categories were comparable (F (3, 56) = 0.031; p = .993). The treatment items and the phonological generalization items involved the same initial phonemes. The treatment items and phonological generalization items with the same

initial phoneme were also of comparable familiarity and of same quantity. The semantic categories involved in the treatment items and those in the phonological generalization items were different. For all the items the subject failed to name in two or more sessions, items with initial phonemes /l/, /j/ or /s/ accounted for the top three highest numbers of errors. Initial phonemes /l/, /j/ and /s/ were therefore chosen as the target phonemes for treatment and phonological generalization items to fulfill the above stated criteria of these two types of items. On the other hand, the treatment items were matched with the semantic generalization items in terms of the semantic categories involved. The initial phonemes involved in semantic generalization items and that in treatment items were different. The control items consisted of items with initial phonemes and categories different from those of the treatment items.

Attribute test was carried out to test the subject's semantic knowledge in the selected 60 probe items. For each item, four yes/no questions concerning the target's properties, location, association, category, use and action were asked. The subject was judged to have preserved knowledge in the item when he could answer three or more questions correctly (Drew & Thompson, 1999). CHT had preserved knowledge in 95% (57/60) of the selected probe items.

Pre-treatment Training

Pre-treatment training was given after the baseline phase to prepare the subject to produce self-generated phonological cue in the treatment phase. The procedure for training was adopted from Law (2006), as described in Appendix B. Although only three initial phonemes were targeted in the treatment items, all Cantonese initial phonemes were targeted in the training to avoid bias in exposure of the phonemes involved in the four types of probe items. The goal for training was spontaneous production of syllables upon presentation of orthographic (letter) cue.

Treatment Phase

At the beginning of each treatment session, the subject was asked to name all the 60 probe items to monitor the treatment progress. No cues or feedback were given. The order of presentation of the items was randomized every session. In treatment, phonological priming was achieved by training items with the same initial phoneme as a group before introducing a different set of items with another initial phoneme. There were three groups of items, representing the initial phonemes [l, j, s]. The order of presentation of the three groups of items

was randomized across treatment sessions because possible fatigue and/ or decrease in attention level over the session might affect treatment effectiveness of the groups of items if the order of presentation across sessions was the same. In the treatment, a cueing hierarchy was adopted (Law, 2006) (see Appendix C for details). A treatment session would end when all the treatment items were presented for two cycles. The treatment phase would be terminated when the subject achieved at least 85% accuracy (13/15) on treatment items in the probing at the beginning of each treatment session over three consecutive sessions.

Maintenance Phase

The aim of this phase was to investigate the endurance of the treatment effects. There were four weekly sessions which began two weeks after the last treatment session to record the subject's naming accuracy of all probe items.

To prove that the increase in naming accuracy if any was attributed to the treatment but not improvement in general conditions of the subject, a control task was included. The control task selected was digit span forward, which is a short term memory task, as it was not related to naming. The control task was carried out in the first and third sessions of the baseline phase, and in the first and third sessions of the maintenance phase.

Data Analysis

Scoring

Each session was tape-recorded using a digital recorder. The naming responses of the subject were transcribed orthographically in the sessions. The subject's naming responses were scored as correct response, alternative response or error response. Only modal names obtained from the normal controls were scored as correct responses. Alternative responses were other appropriate names of the target besides the modal name, that is, naming responses having the same meaning as the modal name but with different wordings (e.g. naming 浴缸 /juk$_{22}$ kɔ ŋ$_{55}$/ (modal name) as 沖涼缸 /ts^{h}uŋ$_{55}$ lœŋ$_{21}$ kɔ ŋ$_{55}$/). Other appropriate name would not be classified as correct response because the other appropriate name may violate the criteria of the type of items it belongs to (e.g. 浴缸 /juk$_{22}$ kɔ ŋ$_{55}$/ was a phonological generalization item, but the other appropriate name 沖涼缸 / ts^{h}uŋ$_{55}$ lœŋ$_{21}$ kɔ ŋ$_{55}$/ did not share

the same initial phoneme as the treatment items). Error responses included 1) Semantic error including 'superordinate naming' defined as production of the category name instead, e.g. 背心 (vest) → 衫 (cloth), 'coordinate naming' defined as naming item from the same category as the target, e.g. 三文治 (sandwich) → 蛋糕 (cake), and 'semantic association' defined as naming the activities or objects associated with the target, e.g. 魚竿 (fishing rod) → 釣魚 (fishing) and 頭髮 (hair) → 梳 (comb); 2) Phonological error which was characterized by substitution of phoneme and 50% or more syllables in the target words were correct, e.g. 散紙包 /san$_{23}$ tsi$_{25}$ pau$_{55}$/ → 眼紙包 /ŋan$_{23}$ tsi$_{25}$ pau$_{55}$/. 3) Partial response defined as partial retrieval of the target name, e.g. 甲蟲 /kap$_{25}$ ts^{h}uŋ$_{21}$/ → 甲 /kap$_{25}$/; 4) Jargon or neologism, e.g. 吸塵機 /k^{h}ɐp$_{55}$ ts^{h}ɐn$_{21}$ kei$_{55}$/ (vacuum cleaner) → 抱頭 /p^{h}ou$_{23}$ t^{h}ɐu$_{21}$/ (hold head); 5) Unrelated responses defined as a meaningful naming response unrelated to the target, e.g. 螺絲釘 (nail) → 鎖匙 (key); 6) English name e.g. 小提琴 (violin) → violin, and 7) No response. When the subject had self-correct, the last response given by the subject would be scored.

Reliability

Inter-rater reliability on classification of the subject's naming responses into the above mentioned categories was obtained. Naming responses in three randomly selected sessions were subjected to reliability check, constituting 21.43% of all sessions including baseline sessions, treatment sessions and maintenance sessions. Point-to-point agreement ranged from 93.33% to 96.67%, with a mean of 94.44%.

Statistical Analyses

McNemar's test was used to evaluate if the subject's naming of treatment items, phonological generalization items, semantic generalization items and control items improved significantly due to the treatment. In each treatment session, the subject named the 60 items before treatment was given in that session. For treatment items, the subject's best performance on naming the items before the treatment protocol was implemented, that is, in the three baseline sessions and the first treatment session, was compared with his best performance on naming treatment items in the subsequent sessions, that is, in the treatment sessions after

session one and the maintenance sessions. Similarly, for phonological generalization items, semantic generalization items and control items, the subject's best performance on naming a particular type of items (e.g. phonological generalization items) in the three baseline sessions and the first treatment session, was compared with his best performance on naming the same type of items in the treatment sessions after session one and the maintenance sessions.

To evaluate whether improvement in naming treatment and generalization items were attributed to the treatment and generalization effects, respectively, or to repeated exposure and naming attempts of the items, comparisons between the subject's performance on treatment and generalization items, treatment and control items and generalization and control items were made. This was done by contrasting the subject's best performances in naming the two types of items in treatment sessions after session one and the maintenance sessions using the chi-square test. In chi-square calculation, the degree of freedom equaled to one and the number of items under consideration was less than 50; therefore, Yate's correction for continuity was used so as to improve the accuracy of the chi-square statistic (Maxwell & Satake, 1997).

Result

Pre-treatment Training and the Levels of Cues the Subject Responded to During Treatment

CHT required six sessions to complete pre-treatment training. During treatment, the subject did not rely on probing to produce self-generated phonological cues (step 2 and 3 in the cueing hierarchy) and could self-generate phonological cues upon presentation of the orthographic (letter) cue. Figure 2 shows the levels of cues CHT required to produce the target names during treatment when he failed to name the items spontaneously.

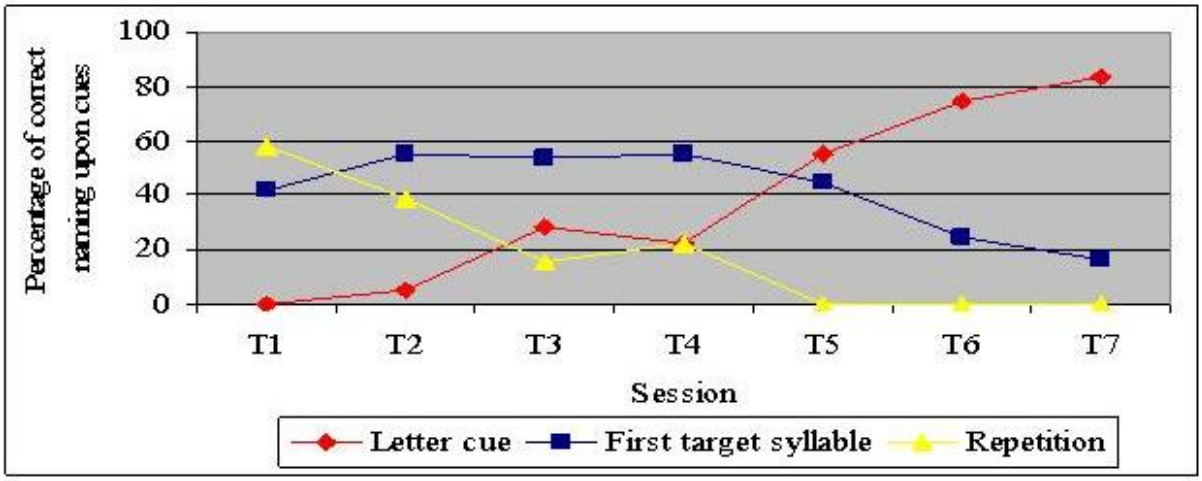

Figure 2. Levels of cues CHT responded to during treatment

As shown in Figure 2, there was a trend of increase in correct production upon self-generated phonological cues with a decrease in reliance on repetition to produce the target.

Progress in the treatment

CHT made good progress in the treatment and reached criteria by the seventh treatment session. Figure 3 shows the subject's progress on naming treatment items, phonological generalization items, semantic generalization items and control items.

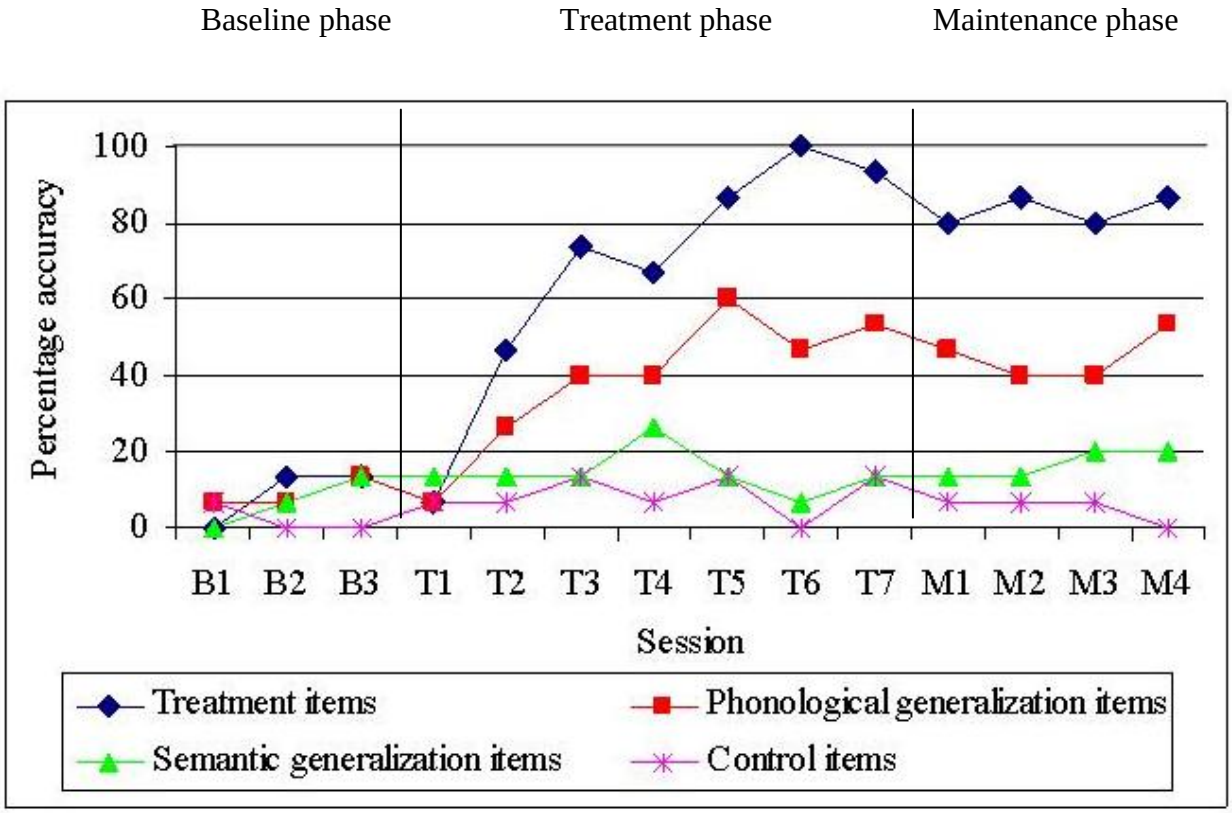

Figure 3. Percentage accuracy in naming different types of probe items across sessions.

The subject's progress in naming the four types of probe items compared with his performance in naming the items before implementation of treatment, that is in B1 to T1, was analyzed statically (Table 1). There was significant improvement in naming treatment items. For generalization items, the change for naming phonological generalization items was significant. On the other hand, insignificant change was found in naming semantic generalization items. Similar observation was made of control items.

Comparisons between best performances on naming different probe types revealed that treatment items were named more accurately than the phonological generalization items, semantic generalization items and the control items, as illustrated in Table 2. A significant

difference was found for naming accuracy between phonological generalization items and control items. For the other contrasts, no significant differences were found.

Table 1

Statistical analyses of improvement in naming different types of probe items

Type of items	Best performance before treatment (B1 to T1) Vs. Best performance in T2 to T7 and maintenance phase	McNemar χ^2	*p*
Treatment items	13.33% (B2, B3) Vs. 100% (T6)	11.077	.0009
Phonological generalization items	13.33% (B1, B3) Vs. 60% (T5)	5.143	.0233
Semantic generalization items	13.33% (B3, T1) Vs. 26.67% (T4)	0.5	.4795
Control items	6.67% (B1, T1) Vs. 13.33% (T3, T5, T7)	0.000	1.0000

Table 2

Comparison of naming accuracy of different types of probe items

Type of items compared	Best performance in T2 to T7 and maintenance phase	χ^2 with Yate's correction	*p*
Treatment Vs. Phonological generalization	100% (T6) Vs. 60% (T5)	7.5	.0062
Treatment Vs. Semantic generalization	100% (T6) Vs. 26.67% (T4)	17.368	.0001
Treatment Vs. Control items	100% (T6) Vs. 13.33% (T7)	22.941	< .0001
Phonological generalization Vs. Control items	60% (T5) Vs. 13.33% (T7)	7.033	.0080
Semantic generalization Vs. Control items	26.67% (T4) Vs. 13.33% (T7)	0.833	.3613

Considering maintenance effect for the types of items having significant improvement, that is, treatment and phonological generalization items, the subject's naming accuracy in the

last maintenance session (M4) and his highest naming accuracy for the corresponding type of item in treatment phase (T2 to T7) was comparable (for treatment item, McNemar $\chi^2 = 0.500$, $p = .4795$; for phonological generalization items, McNemar $\chi^2 = 0.000$, $p = 1.0000$).

Error Pattern Changes in Naming the Probe Items

The changes in error pattern throughout the study are shown in Figure 4. Alternative response was produced only twice, once in treatment session seven and once in maintenance session three. There was a clear trend of reduction of no responses with increase in partial responses across sections. Semantic errors fluctuated throughout the study. The percentage of semantic errors before implementation of treatment (in B1 to T1) was comparable to that in the maintenance phase, accounting for 43.50% and 41.89% of all errors respectively. Unrelated errors had very little change. Unrelated errors, jargons, English names and phonological errors remained low in percentage. Nonetheless, it should be noted that there was no phonological errors in B1 to T1 while there was a few in the maintenance phase.

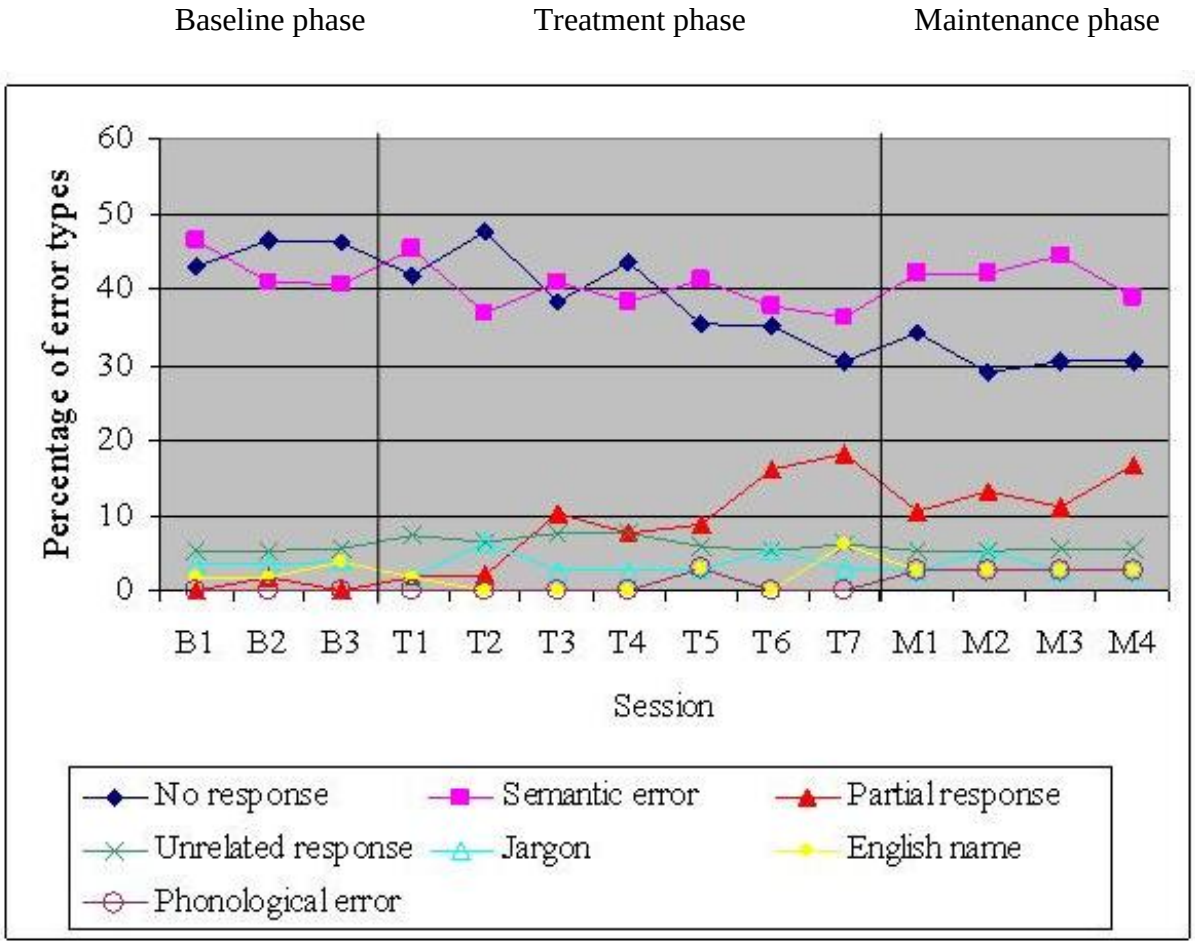

Figure 4. Error pattern changes across sessions

Summary of Main Findings

To sum up, CHT was more responsive to self-produced phonological cues during treatment across treatment sessions. There was significant gain in naming treatment items and phonological generalization items. The treatment effect was maintained for at least one and a half month after the end of treatment. No responses decreased with an increase in partial responses and phonological errors.

Discussion

Pre-treatment Training

CHT required six sessions to complete pre-treatment training. The four subjects reported by Law (2006) took two to seven sessions to pass through the pre-treatment training phase. As the pre-treatment training required the production of syllables upon orthographic presentation of an initial phoneme, the subjects' post-morbid ability in letter sounding should be important in the pre-treatment training phase. It was found that the subjects' (CHT and the four subjects in Law (2006)) ability in letter sounding was negatively correlated with the number of sessions needed to complete the pre-treatment training phase (r = -0.974, p = .005). Although relatively more pre-treatment training sessions were needed for patients with poor letter sounding, it was encouraging that they all passed the pre-treatment training phase, including a subject in Law (2006) who failed to perform letter sounding at all in the initial assessment.

The pre-treatment training phase may seem long when compared with the treatment phase in this study which only took seven sessions. In real clinical practice, the letter sounding knowledge learnt in the pre-treatment training phase can be used throughout the treatment phase which should be longer with the introduction of many more items than that in the study. Also, the skills of letter-sound mapping and the use of letter cue to self-generate phonological information can be extended to situations outside of the clinics. For example, the patient's caregiver could give the patient the orthographic cue of a particular object and train the patient to name the object. And the patient may remember the orthographic cue of the object and make use of the cue to self-generate phonological information in times of failure in word retrieval.

Responsiveness to Cues during Treatment

It was observed that the subject could consistently self-generate phonological cues upon presentation of the orthographic cue. This illustrated that letter-sound knowledge learnt in the pre-treatment training was maintained in the treatment phase. The subject was more responsive to self-generated phonological cues across treatment sessions, demonstrating the effectiveness of the orthographic-phonological cue (Hickin et al., 2002).

Specific Treatment Effect

The result indicated that there was significant improvement in naming treatment and phonological generalization items. The subject's accuracy in naming treatment and phonological generalization items was significant better than his accuracy in naming control items respectively. Also, CHT's performance in the control task (digit span forward) remained constant. These indicated that his significant improvement in naming treatment and phonological generalization items was attributed to specific treatment effect but not spontaneous recovery or other factors resulting in general improvement of the subject.

CHT's naming accuracy of different probe items was stable before the introduction of treatment. When treatment was introduced, there was a prominent increase in naming accuracy of treatment items and phonological generalization items. These further supported that significant improvement in naming the two types of items was attributed to treatment effect.

Generalization Effect

Although Nickels (2002) proposed that repeated attempts to name certain items would improve subsequent naming of the items despite no feedback was provided, the significant improvement in naming phonological generalization items found in this study cannot be explained by repeated naming. It was because if repeated naming was the reason for significant improvement, there should also be significant improvement in naming semantic generalization items and control items but this was not the case.

Generalization effect from treatment employing phonological cueing hierarchy was found to be mixed. Studies had found no generalization (e.g. Miceli et al., 1996), specified generalization, where improvement was found in naming untreated words that belonged to the same phonological domain as the treated items (e.g. Raymer et al., 1993) and unspecified

generalization, where an improvement of untreated words was found, without clear statement/ investigation of the nature of the untreated words (e.g. Robson et al., 1998). In contrast to these mixed generalization results from phonological cueing hierarchy studies, studies on treatment employing repetition only (oral repetition or oral reading with the presence of pictures) had not found generalization to untrained words either in patients with phonological impairments (e.g., Hillis & Carramazza, 1994; Miceli et al., 1996) or in patients with multilevel impairments (Greenwald, Raymer, Richardson & Rothi, 1995; Nickels & Best, 1996). In addition, Renvall et al. (2003) reported a single case study on anomia treatment in which the subject was asked to repeat object names in the presence of pictures with the incorporation of phonological priming. Phonological priming was achieved by using treatment items sharing the same initial consonants and having similar number of syllables. Again, no generalization to phonologically related items was found. A similar case was reported in Laine and Martin (1996). In other words, treatment studies employing repetition alone with or without phonological priming had not found generalization effect. Patient has to reflect on the phonological representation of the targets when phonological cues are provided. On the other hand, the patient does not have to do so in the passive process of repetition. The above studies revealed that active participation of the patient in reflecting on the phonological representation of the targets may be a necessary condition for generalization to occur. As in this study, the subject had to generate syllables associated with the orthographic cues and think of the target names during the production of various syllables.

One of the subjects (LKH) reported by Law (2006) demonstrated similar deficits in repetition, non-verbal semantic tests and verbal semantic tests as CHT. And as LKH, CHT had more severe deficit in oral naming than reading aloud object names (see Table 3). In this study, CHT demonstrated significant improvement in naming phonological generalization items. On the contrary, LKH did not improve in naming phonological generalization items. LKH received treatment using orthographic-phonological cue without the incorporation of phonological priming in the treatment. The above result implies that phonological priming may facilitate generalization to phonologically related items as predicted.

Table 3

CHT's and LKH's scores[1] in different assessments

	CHT	LKH
Repetition (n=30)	25 (83.33%)	24 (80%)
Oral naming (n=217)	103 (47.47%)	125 (57.6%)
Reading aloud object names (n=217)	157 (72.35%)	195 (89.9%)
Verbal semantic tests		
Spoken word-picture matching (n=126)	113 (89.68%)	112 (88.9%)
Synonym judgment (n=60)	37 (66.67%)	35 (58.3%)
Non-verbal semantic tests		
PPT (n=37)	36 (97.3%)*	31 (83.8%)*
associative match test of BORB (n=23)	22 (95.65%)*	22 (95.7%)*

Note. [1] LKH's scores were from Law (2006); *the scores are within one standard deviation compared to the normal population (Law et al., 2006)

Caramazza and Hillis (1993) and Miceli et al. (1996) proposed a model in which there was a one-to-one relationship between a semantic representation and its corresponding phonological forms. Based on the model, Miceli et al. (1996) claimed that phonologically based treatment strengthened specific connections from a word's semantic specification to its phonological code and should not result in generalization to untrained items. The significant improvement in naming phonological generalization items found in this study did not support Miceli et al.'s (1996) prediction. Instead, the generalization supported the interactive activation models of naming. The model stated that phonological neighbors of the target also achieved some degree of activation and thus, some long-term strengthening of lexical access (Dell et al., 1997). Activation of the phonological generalization items may come from two sources in the present treatment protocol. Firstly, the production of treated items resulted in spreading activation to the phonological generalization items as they shared the same initial phonemes. Secondly, in the treatment, when the subject produced syllables associated with the presented orthographic cue, there should be spreading activation to the phonological generalization items sharing the same initial phoneme.

Insignificant Gain in Semantic Generalization Items

Although the subject in this study had significant improvement in naming phonological generalization items, insignificant improvement was found in naming semantically related items. It seemed that the result contradicted Dell et al.'s (1997) interactive activation models; however, the subject's negative improvement in naming semantically related items should be explained by the characteristics of his deficits or the nature of the treatment protocol.

Theoretically, even when there was spreading activation to the semantic concepts of the semantically related items by naming the treatment items, the patient's ability in naming the semantically related items would not improve if the patient already has the semantic concepts of the semantically related items and his failure in naming those items is attributed to post-semantic deficits. The study by Greenwald et al. (1995) and Hillis and Carramazza (1994) had shown generalization to semantically related words following phonological treatment in patients with primarily deficits in semantic system. On the other hand, phonological cueing studies did not find generalization to semantically related items in patients with phonological deficits with relatively spared semantic system (Hillis & Carramazza, 1994; Thompson, Raymer & LeGrand, 1991). In the present study, CHT's had preserved semantic knowledge in majority of the semantic generalization items as revealed in the attribute test and his naming difficulty was mainly attributed to deficits in the phonological output lexicon and/ or the access to it. Consistent with the studies by Hillis and Carramazza (1994) and Thompson et al. (1991), CHT had insignificant gain in naming semantic generalization items. The above studies supported that generalization to semantically related items may only be found in patients whose naming deficits are mainly attributed to semantic impairment.

Apart from CHT's deficits, the insignificant improvement may also be explained by the nature of the treatment. Thompson et al. (1991) claimed that phonological cueing hierarchy used in treatment provided no semantic information in any of its step, and thus treatment using phonological cues may not result in spreading activation to semantic concepts that are strong enough to aid retrieval of semantically related items.

CHT's error pattern supported that the treatment may not involve a strong activation of the semantic system as claimed by Thompson et al. (1991). The percentage of semantic errors in

the maintenance phase (41.89%) was comparable to that before treatment (43.50%). The no change or even slight decrease in semantic errors was in contrast to the error pattern change as observed in semantic treatments. Law et al. (2006) found that three subjects who underwent treatment using SFA and semantic priming produced more semantic errors subsequent to intervention. According to Law et al. (2006), the increase in semantic errors demonstrated spreading activation to the semantically related neighbors of the targets. Considering this, the no change or even slight decrease in semantic errors for CHT may demonstrate that there was weak spreading activation to semantically related neighbors in naming treatment items. This revealed that phonological based treatment may be less prone to result in generalization to semantically related items.

Changes in Error Pattern

Considering the changes in error pattern, it was also noted that there was reduction of no responses with increase in partial responses and phonological errors. No responses can be explained by difficulties in lexical access (Caramazza & Hillis, 1993). The reduction in no responses across the sessions revealed that the treatment resulted in improved lexical access. Besides decrease in no response, the increase in phonological correspondence to the target words in the errors also suggested improved access to phonological representations of words (Renvall et al., 2003). There were two explanations for the improved access. Firstly, the improvement in access to phonological lexicon may be explained by interactive activation models of naming (Dell et al., 1997). The model stated that phonological and semantic neighbours of the produced target also achieve some degree of activation. Through spreading activation, the access to partial phonological forms which shared semantic or phonological information as the produced targets was strengthened (Dell et al., 1997). Another explanation of improvement in lexical access was that repeated attempt to name certain pictures would improve lexical access of the items despite no feedback was provided as proposed by Nickels (2002). CHT's repeated naming of the items may result in improved access to the items, although this does not necessarily result in correct naming.

CHT's error pattern change was consistent with previous studies on phonologically based treatment. Jokel, Rochon and Leonard (2004) found that the provision of phonologically based

treatment had led to increase in errors that carry phonological resemblance to the target. Similarly, Martin and Laine (2000) also reported an increase in phonologically related errors upon treatment using repetition coupled with phonological priming. Using the same treatment protocol as Martin and Laine (2000), Renvall et al. (2003) found an increase in phonological correspondence to the target words in the errors with decrease in no responses.

Limitation

Anomia also affects discourse production (Armstrong, 2000). The ultimate goal of speech-language treatment for aphasia is generalization to natural discourse context (Caramazza & Hillis, 1993). Changes in discourse production were not investigated in this study. Of the three investigations that studied the changes in discourse production upon intervention on confrontation naming, one reported improvements (Coelho, McHugh & Boyle, 2000), one found improvement on some, but not all, discourse measures (Boyle, 2004) and the other reported no changes in the discourse outcome measures that were used (Boyle & Coelho, 1996). In view of these, it was uncertain if the subject's gain in confrontation naming in treatment setting facilitated his discourse production.

Suggestion for Further Study

Further study can be done on investigation of changes in discourse production upon implementation of phonologically based anomia treatment.

The use of orthographic-phonological cue and phonological priming in anomia treatment seems promising in promoting generalization which accounts for treatment effectiveness (Nickels, 2002). Further research on treatment using orthographic-phonological cue and phonological priming to different patients can be carried out to improve the external validity of the treatment protocol.

In Law et al. (2006), four semantic tests including synonym judgment, spoken word-picture matching, PPT and BORB were used to rate the severity of semantic impairment (Appendix D shows the detail criteria). Phonologically based treatment had been shown to be effective for Cantonese anomia patients with very mild to moderate semantic impairment in this study and in Law (2006). However, it cannot be assumed that patients with severe semantic impairment can also benefit from phonologically based therapy. Indeed, Best et al.

(2002) found that phonologically based treatment had greater effect for patients who had relatively less difficulty at the level of semantics. Further investigation can be done on investigating the treatment effectiveness of phonologically based treatment on patients with severe semantic impairment.

Conclusion

This study demonstrated that treatment using orthographic-phonological cue and phonological priming was effective in promoting word retrieval of a Cantonese anomic patient. Generalization to phonological generalization items was found while there was no significant gain in semantic generalization items. The significant improvement in naming phonological generalization items seems to support the interactive activation model and that phonological priming may promote generalization. The insignificant gain in semantic generalization items may be explained by the characteristics of the subject's deficits or the nature of the treatment protocol.

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Appendix A

Probe items used in this study

	Items	Familiarity rating	Initial phoneme	Category
Treatment items	領呔	3	l	clothings
	涼鞋	2.6	l	clothings
	暖水壺	2.6	l	kitchen ware
	溜冰鞋	1.2	l	recreation
	騾仔	1.4	l	animals
	煙斗	1.2	j	personal belongings
	衣夾	3.2	j	household
	搖搖	1.4	j	recreation
	魚竿	1.8	j	recreation
	衣架	3.8	j	household
	信封	3.4	s	stationery
	鎖匙	4.6	s	personal belongings
	三文治	3.2	s	food
	散紙包	2.4	s	personal belongings
	犀牛	1.4	s	animals
Phonemic generalization items	垃圾車	3	l	transportation
	檸檬	3.4	l	fruit and vegetables
	喇叭	1.4	l	musical instruments
	螺絲帽	2.8	l	tools
	螺絲釘	2.8	l	tools
	鸚鵡	1.8	j	birds
	洋蔥	3.4	j	fruit and vegetables
	耳仔	4.4	j	body parts
	浴缸	4.2	j	toiletry
	衣櫃	3.8	j	furniture
	手風琴	1.4	s	musical instruments
	小提琴	1.8	s	musical instruments
	舢板	1.4	s	transportation
	收音機	3.6	s	electrical appliances
	士巴拿	2.4	s	tools

	Items	Familiarity rating	Initial phoneme	Category
Semantic generalization items	滑梯	1.8	w	recreation
	乒乓波拍	2.2	p	recreation
	保齡球	2.2	p	recreation
	銀包	4.4	ŋ	personal belongings
	頸鍊	1.8	k	personal belongings
	鞋架	2.4	h	household
	燙衫板	3	t^h	household
	煤氣爐	2.8	m	kitchen ware
	畫筆	2	w	stationery
	箭豬	1.4	ts	animals
	袋鼠	1.6	t	animals
	泳衣	2.6	w	clothings
	工人褲	2.4	k	clothings
	背心	2.8	p	clothings
	花生	3.2	f	food
Control items	拖車	1.8	t^h	transportation
	快艇	1.4	f	transportation
	直昇機	2	ts	transportation
	貨櫃車	3.2	f	transportation
	吸塵機	3.6	k^h	electrical appliances
	蜜桃	2.6	m	fruit and vegetables
	青椒	3	ts^h	fruit and vegetables
	冬菇	2.8	t	fruit and vegetables
	口琴	1.8	h	musical instruments
	木琴	1.6	m	musical instruments
	蝸牛	2	w	insects
	草猛	1.6	ts^h	insects
	甲蟲	1.6	k	insects
	額頭	3.6	ŋ	body parts
	頭髮	4.8	t^h	body parts

Appendix B

Pre-treatment training procedure

Romanization system was used in training (Law, 2006). For example, for the phoneme which is represented as 'p^h' in IPA and is represented as 'p' in Romanization system, the letter 'p' will be used to train the subject to produce the target phoneme. Romanization system was used because normal populations learn letter sounds in Romanization system. For example, when given the letter 'p', people may know it has the sound of the first phoneme of 'pen'. But people may not know 'p^h' is representing the same sound. The procedure of pre-treatment training was as follows:

1. Training follows the sequence of *f, s, m, p, b, l, h, ch, j, w, t, d, k, g, kw, gw, y*.
2. Groups of two to three letters were trained one at a time, focusing on [a, i, u]. Take the letter *s* as an example – i) clinician presented the letter *s* on a piece of paper and produced [sa, si, su]; ii) subject repeated after the clinician; iii) clinician presented another letter. The goal was spontaneous production of the target syllables upon presentation of the letter.
3. After the subject could produce CV syllables with vowels [a, i, u] for all the letters, same groups of letters were targeted, focusing on other vowels. The goal for the subject was spontaneous production of syllables containing vowels other than [a, i, u], e.g., [sy, sɔ].

Appendix C

Cueing hierarchy used in treatment

1. Present an object
2. If fails to name, present a letter cue, e.g. *s.*

   The subject may produce self-generated phonological cues
3. Clinician demonstrating phoneme + schwa, e.g. [sə]
4. Clinician prompting the subject to generate possible CVs, e.g. [sa, si, su, sɛ]
5. Clinician providing first target syllable
6. Provision of target name; subject repeats after the clinician
7. Another object

Appendix D

Criteria for rating the severity of semantic impairment

Performance in a semantic task was considered below normal if

1. the score fell outside of the normal range in the case of synonym judgment
2. more than 5 errors made in the case of spoken word-picture matching.
3. the score fell below one standard deviation of the mean in the case of PPTT and BORB.

The severity of semantic impairment was rated objectively as follows: one semantic test below normal – very mild, two semantic tests below normal – mild, three tests below normal – moderate and all the four semantic tests below normal – severe.